19. An electronic apparatus according to claim 18; wherein the insulating layer is formed of one of an engineering ceramic, alumina, zirconia and silicon nitride.

20. An electronic apparatus according to claim 13; wherein the moving body is alumited and the oscillating member is formed of one of aluminum and aluminum alloy and has plural faces in contact with the moving body.

21. An electronic apparatus according to claim 13; wherein the volume resistivity of the insulating material is above $10^5\Omega$-cm.

ADDITIONAL FEES:

A check in the amount of $18.00 is enclosed to cover the cost of one additional claim in excess of 20 total. Should the check prove insufficient for any reason, authorization is hereby given to charge any such deficiency to our Deposit Account No. 01-0268.

REMARKS

In the last Office Action, dated December 27, 1999, claims 1-9 were rejected under 35 U.S.C. §112, first paragraph, as containing subject matter which is not described in the specification. The Examiner stated that the drive

circuit referred to in the specification by reference numeral 11 [sic] is not described or illustrated in such a way that one of ordinary skill in the art can figure out how it physically and electrically relates to the motor structure.

Claims 1-9 were further rejected under 35 U.S.C. §112, second paragraph, as being indefinite. The Examiner stated that the claims are vague, indefinite and contradictory in that the power source (claim 1, line 3) is insulated from the piezoelectric material (claim 1, lines 11-15). The Examiner questioned how such a device can operate if the power source is insulated from the transducer electrodes.

Claims 1, 9/1, 8 and 9/8 were rejected under 35 U.S.C. §102(a) as being anticipated by each of Tokusima, Kanazawa and Kawai. Claims 2, 9/2, 3 and 9/3 were rejected under 35 U.S.C. §102(a) as being anticipated by each of Japan '565 and Sumihara. Claims 4 and 9/4 were rejected under 35 U.S.C. §102(a) as being anticipated by Sumihara. Claims 5 and 9/5 were rejected under 35 U.S.C. §102(a) as being anticipated by Inagaki (U.K.). Claims 6, 9/6, 7 and 9/7 were rejected under 35 U.S.C. §103(a) as being unpatentable over Kawai, Tokusima, or Kanazawa in view of Japan '783. The Examiner stated that the references teach the ultrasonic motor structure except for the provision of a ceramic wear/ insulating layer, but that Japan '783 teaches the use of a

ceramic layer for wear protection, while Kanazawa teaches providing an alumited "insulator on an aluminum stator (citing col. 5, lines 55-68). The Examiner stated that since selection from known materials has long been considered obvious to one of ordinary skill in the art, it would have been obvious to use an aluminum oxide or a ceramic wear coating in Kawai, Tokusima or Kanazawa.

Applicants respectfully traverse the rejection under 35 U.S.C. §112, first paragraph, and respectfully submit that the drive circuit 11 is adequately described and illustrated in the specification in accordance with the requirements of §112. "[T]he 'essential goal' of the description of the invention requirement is to clearly convey the information that an applicant has invented the subject matter which is claimed." <u>In re Barker</u>, 559 F.2d 588, 592 n.4, 194 USPQ 470, 473 n.4 (CCPA 1977), <u>cert. denied</u>, 434 U.S. 1064 (1978). While it is necessary for a patent applicant to provide a clear description of the inventive elements of a claim and the manner in which those elements cooperate, the applicant is not required to describe known elements of a claim. As to known elements, it is well established that an applicant's use of a "black box" is sufficient to satisfy the written description requirement. In fact, use of a black box to convey a known structure is a preferred practice. <u>See</u> 37 C.F.R. §1.83(a).

An applicant's specification must convey with reasonable clarity to those skilled in the art that, as of the filing date sought, he or she was in possession of the claimed invention. Vas-Cath, Inc. v. Mahurkar, 935 F.2d 1555, 1563-64, 19 USPQ2d 1111, 1117 (Fed. Cir. 1991). The courts have described the essential question to be addressed in a written description inquiry in a variety of ways. An objective standard for determining compliance with the written description requirement is, "does the description clearly allow persons of ordinary skill in the art to recognize that he or she invented what is claimed." In re Gosteli, 872 F.2d 1008, 1012, 10 USPQ2d 1614, 1618 (Fed. Cir. 1989). Under Vas-Cath, Inc. v. Mahurkar, 935 F.2d 1555, 1563-64, 19 USPQ2d 1111, 1117 (Fed. Cir. 1991), to satisfy the written description requirement, an applicant must convey with reasonable clarity to those skilled in the art that, as of the filing date sought, he or she was in possession of the invention, and that the invention, in that context, is whatever is now claimed. The test for sufficiency of support in a patent application is whether the disclosure of the application relied upon "reasonably conveys to the artisan that the inventor had possession at that time of the later claimed subject matter." Ralston Purina Co. v. Far-Mar-Co., Inc., 772 F.2d 1570, 1575, 227 USPQ 177, 179 (Fed. Cir. 1985)

(quoting In re Kaslow, 707 F.2d 1366, 1375, 217 USPQ 1089, 1096 (Fed. Cir. 1983)).

Whenever the issue arises, the fundamental factual inquiry is whether a claim defines an invention that is clearly conveyed to those skilled in the art at the time the application was filed.

Applicants respectfully submit that their specification satisfies the written description requirement of 35 U.S.C. §112, first paragraph. The drive circuit utilized in the preferred embodiments of the invention comprises a self-oscillation drive circuit of the type which is well known to those skilled in the art. In view of the prior art knowledge of this conventional device, applicants' description of this circuit need convey only that it is well known. Applicants have satisfied this basic requirement at pg. 1, lines 14-16 of the specification.

Furthermore, that a self-oscillating drive circuit is utilized in the preferred embodiments is further described at pg. 1, line 15 - pg. 2, line 5 of the specification. An illustration of the self-oscillating drive circuit is provided in Fig. 10 of the application drawings and described at pg. 12 of the specification. The self-oscillating drive circuit of Fig. 10 comprises an oscillation drive circuit 32, piezoelectric element 4 and oscillating body 3.

A typical self-oscillating drive circuit is illustrated schematically in attached explanatory diagram 1. The self-oscillating drive circuit comprises a piezoelectric vibrating member 5, an amplifying circuit and a filter circuit. The amplifying circuit comprises a first inverter 13a having an input end connected to a detecting electrode 12c of the piezoelectric element 5 serving as a vibrating member 5, a resistor 13b connected in parallel with the first inverter 13a, a second inverter 13c, and a resistor 13d connected in parallel with the inverter 13c. The filter circuit comprises a resistor 14b having one end connected to an inverted output terminal of the first inverter 13a and the other end connected to an input terminal of the second inverter 13c, and a capacitor 14a having one end connected to the resistor 14b and the other end grounded.

The first inverter 13a amplifies a signal at the detecting electrode 12c of the piezoelectric element 4. The resistor 13b feeds back the drive signal thus amplified to the input terminal of the first inverter 13a, thereby setting an operation point. The capacitor 14a and the resistor 14b remove frequency components other than the desired drive frequency component from the amplified drive signal. The drive signal is then amplified by an amplifying circuit formed by the second inverter 13c and the resistor 13d, and applied to the driving electrode 12a.

The use of feedback resistors for feeding back a portion of the detected drive signal in the above-described manner causes the circuit comprising the amplifying circuit, the filter circuit and the piezoelectric element 4 to undergo self-excited oscillation, and the circuit is thus referred to as a self-oscillating drive circuit.

The self-oscillating drive circuit illustrated in Fig. 10 of the application drawings is similar to that described above. The self-oscillation drive circuit 32 produces a drive signal applied to electrodes 8a, 8b and 8b' of the piezoelectric element 4. In Fig. 10, a normal-reverse rotation signal generating means 30 and a switching circuit 31 are further provided so that the standing wave generated by the piezoelectric element 4 can be selectively directed to rotate a moving body 5 in forward or reverse directions.

Since the self-oscillating drive circuit is known, as described in a published patent application identified by applicants at pg. 1 of the specification, and is illustrated in Fig. 10 and described in the specification, applicants respectfully submit that the subject matter of claims 1-9 is adequately described by the specification, and that the rejection of claims 1-9 under 35 U.S.C. §112, first paragraph, should be withdrawn.

With respect to the Examiner's rejection of claims 1-9 under 35 U.S.C. §112, second paragraph, applicants respectfully note that the claims recite, inter alia, an ultrasonic motor comprising a driving circuit, a power source for powering the driving circuit, an oscillating member driven by the driving circuit and a moving body contacting and being driven by the oscillating member in response to oscillation thereof.

The Examiner's conclusion that the claimed device cannot operate if the power source is insulated from the transducer electrodes is incorrect. The power source drives the driving circuit to generate self-excited oscillation along with the oscillating member. Claim 1 does not require the power source to supply power to the oscillating member and thus does not recite an inoperative device if the power source and the oscillating member are insulated from each other in the claimed manner.

Accordingly, applicants respectfully submit that the rejection of claims 1-9 under 35 U.S.C. §112, second paragraph, is in error and should be withdrawn.

Applicants respectfully traverse the prior art grounds of rejection.

The present invention relates to an improved structure for an ultrasonic motor in which insulation is

provided between the power source of the self-oscillating drive circuit and the piezoelectric element of the motor. In a preferred embodiment, the ultrasonic motor comprises an oscillating body, a piezoelectric element, an oscillation drive circuit and various other members (e.g., a supporting mechanism, a moving body and a pressing mechanism).

As pointed out by applicants at pages 1-2 of the specification, a wide variety of electronic devices are commonly equipped with an ultrasonic motor for use as a source of motive power. An illustration of a typical analog clock having such a construction is shown in Fig. 11 of the application drawings. An oscillating body 3 having a piezoelectric device 4 bonded thereto generates an oscillatory wave by self-excited oscillation to drive a moving body 5. A base plate 21 is directly connected to the positive terminal of a power supply for driving the clock and serves as a lead wire for carrying a positive potential to the movement. When an ultrasonic motor is mounted to the base plate 21, electrodes of the piezoelectric device 4 short-circuit with the positive power supply terminal through the base plate 21 and stable driving becomes impossible. As a result, in order to mount a self-excited oscillation circuit (or self-oscillating drive circuit) for an ultrasonic motor, it is necessary to form the base plate of an insulating material or

to provide a separate insulator between the base plate and the ultrasonic motor.

This is because the various components of the ultrasonic motor, including the oscillating member, the moving body, the output means, and a pressing mechanism, are typically formed of conductive materials. When a voltage is applied to the base plate 21, a current path can easily be formed between at least one of the electrodes of the piezoelectric element and at least one of the power supply terminals. This makes stable driving of the motor impossible. Since various components of the ultrasonic motor are formed of conductive materials, it becomes necessary to terminate the current path between the power supply and the piezoelectric device by forming components of the electronic device contacting the ultrasonic motor of a non-conductive material. However, this imposes restrictions on the electronic device structure in which the ultrasonic motor is mounted. In a small electronic device, it is difficult to provide an insulating structure due to space restrictions and, if an insulating structure is mounted therein, it may be difficult or impossible to also mount an ultrasonic motor.

The present invention overcomes the foregoing difficulties by providing an ultrasonic motor which can be mounted in an electronic device without imposing structural

restrictions on the electronic device. In accordance with the present invention, the ultrasonic motor comprises an oscillating member for generating an oscillatory wave, a moving body frictionally driven by the oscillatory wave, a pressing mechanism for pressing the oscillating member against the moving body, and output means for transmitting an output force of the moving body for driving an external component. At least one of the oscillating member, the pressing mechanism, the moving body and the output means is formed of an insulating member.

As a result of the foregoing structure, a current path is not formed between a power supply terminal and an electrode of a piezoelectric element since at least one of the oscillating member, the pressing mechanism, the moving body and the output means forming the ultrasonic motor is insulative in nature. It is thus possible to realize an ultrasonic motor which does not impose structural restrictions on a device in which it is mounted.

In accordance with the present invention, when output means for transmitting an output torque is provided on the moving body, the above-described problem can be solved by forming the output means of an insulating material. By such a construction, the object of the invention can be achieved without imposing restrictions on the shape and/or the

materials of the oscillating member and the moving body, which relate closely to the output performance of the ultrasonic motor.

As illustrated in Figs. 1 and 2 of the application drawings, for example, an ultrasonic motor is provided in which a current path between a power supply 10 included in a driving circuit 11 and an ultrasonic motor is cut off by virtue of the structure of the ultrasonic motor, so that no structural restrictions are imposed on an electronic device in which the ultrasonic motor is incorporated.

As shown in Fig. 1, a driving signal generated by the driving circuit 11 powered by a power supply is applied to a piezoelectric element 4. The driving signal causes the piezoelectric element 4 to oscillate, and the amount and direction of displacement are determined by an oscillating body 3 to which the piezoelectric element 4 is bonded. A moving body 5 having a movement direction confined by a supporting mechanism 9 and pressed against the oscillating body 3 by a pressing mechanism 7 is moved by the oscillation of the oscillating body 3, and an output is applied outside the motor by an output extracting gear 6.

More specifically, as shown in Fig. 2, a supporting plate 1 of the ultrasonic motor is formed of an insulating material, and a center shaft 2 mounted on the supporting plate

1 is completely isolated from outside current. A piezoelectric element 4 having electrode patterns 8a, 8b, 8b' provided on its front and rear sides is bonded to an oscillating body 3 fixed to the center shaft 2. A moving body 5 is rotatably mounted on the center shaft 2. The moving body 5 is pressed against the oscillating body 3 by a pressing spring 7 mounted on the supporting plate 1. The driving circuit 11 supplies a driving signal to the piezoelectric device 4 through the electrode patterns 8a, 8b, 8b' enabling the generation of a progressive wave or a standing wave such that the oscillating body 3 oscillates in the circumferential direction with a secondary oscillation mode. As a result of oscillation of the piezoelectric element 4 and production of the standing wave in the oscillating body 3, the moving body 5 rotates about the center shaft 2.

A gear 6 formed of a plastic material and serving as output means is provided on the moving body 5. Although the gear 6 is formed separately from the moving body 5, it may instead be molded integrally therewith. The rotational movement of the moving body 5 is output from the ultrasonic motor by the gear 6. Because the output extracting gear 6 and the supporting plate 1 are formed of insulating materials, there is no current path between the ultrasonic motor and the power supply.

Elimination of the current path between the power supply and the ultrasonic motor is not limited to formation of the output extracting gear 6 and the supporting plate 1 of insulating members as shown in Fig. 2. It is necessary only for one or more members of a current path to be formed of an insulating material, i.e., at least one of the oscillating member, the pressing mechanism, the moving body and the output means.

In operation, an alternating voltage is supplied to the electrodes provided on the front and rear sides of the piezoelectric device 4 by the driving circuit 11, and the moving body 5 is driven by way of friction by an oscillatory wave generated in the oscillating body 3 as a result. In the prior art, when an ultrasonic motor is mounted in an electronic device, if conductive components of the device become electrically shorted with at least one of the power supply terminals, the electrodes of the piezoelectric device may become shorted with the power supply terminal through the output means and/or the supporting plate of the ultrasonic motor, and stable driving becomes impossible.

In accordance with the above-described embodiment, the supporting plate 1 and the gear 6 are formed of insulating materials, so that the electrodes of the piezoelectric device are electrically isolated from device components outside the

ultrasonic motor. It is thus possible to realize a stable ultrasonic motor which is not adversely affected by the construction of the device in which it is mounted.

In the above-described embodiment, because the current path between the power supply 10 and the ultrasonic motor is cut off by components of the ultrasonic motor, the ultrasonic motor does not impose structural restrictions on the electronic device in which it is mounted.

In another embodiment illustrated in Figs. 3 and 4 of the application drawings, the oscillating body 3 to which is bonded the piezoelectric device 4 having the electrode patterns 8a, 8b, 8b' is formed of an insulating material such as plastic. The oscillating body 3 thus terminates a current path between the power supply 10 and the ultrasonic motor. Even if the supporting plate 1, the center shaft 2 and the moving body 5 are formed of a conducting materials, there is no influence on the driving of the ultrasonic motor. Consequently, no structural restrictions are imposed on an electronic device in which the ultrasonic motor is mounted.

In the embodiment shown in Figs. 5 and 6 of the drawings, the supporting plate 1, the moving body 5 and the output extracting gear 6 are formed of an insulating material such as plastic and the moving body 5 and the gear 6 are integrally molded. Since the contacting surfaces of the

supporting plate 1 and the oscillating body 3 are insulating, there is no current path between the power supply 10 and the ultrasonic motor.

Forming the moving body 5 and the gear 6 in an integrally molded fashion results in an increase in the degree of freedom of the output extraction. Thus, for instance, by making a thin moving body thin and beveling the gear as shown in Fig. 6, the direction of the output force of the motor can be altered and it becomes possible for the orientation in which the ultrasonic motor is mounted in an electronic device to be selected variously.

In another embodiment illustrated by Figs. 7 and 8, an insulating layer 12 is formed on the supporting plate 1 and on the surfaces of a metal oscillating body 3 which make pressing contact with the moving body 5. Accordingly, a current path between the power supply 10 and the ultrasonic motor is cut off and no structural restrictions are imposed on an electronic device in which the ultrasonic motor is mounted.

The insulating layer 12 may be formed of an engineering ceramic such as alumina, zirconia, silicon nitride, titanium nitride or DLC (diamond-like carbon) or of an insulating plastic, or an oscillating body 3 having improved insulativity and wear resistance is made by using aluminum or an aluminum alloy and conducting alumite

processing on the contacting surfaces of the oscillating body 3 against which the moving body 5 presses to provide the insulating layer 12.

Figs. 9 and 10 show an embodiment of an ultrasonic motor incorporated in an electronic device and a self-oscillation drive circuit of the ultrasonic motor. A signal generated by an oscillation driving circuit 32 is supplied to electrode patterns 8a, 8b, 8b′. It is possible to decide to which electrode pattern the driving signal is transmitted by transmitting a signal from a normal-reverse rotation signal generating means 30 to a switching circuit 31. The ultrasonic motor is used as a motive power source of the analog electronic clock.

An insulating plastic oscillating body 3 of the kind shown above is mounted on a center shaft 2, and the center shaft 2 is fixed to a base plate 21 by a fastening screw 22. A piezoelectric device 4 having electrode patterns 8a, 8b, 8b′ provided on its front and rear sides is bonded to the oscillating body 3. The moving body 5 is rotatably mounted on the center shaft 2, and the moving body 5 is pressed against the oscillating body 3 by a pressing spring 7 mounted on the base plate 21. An insulating plastic gear 6 serving as output means is disposed on the moving body 5, and this gear 6 rotates a number four gear 23 and further rotates a number

three gear 24, a minute gear 25, a day gear (not shown) and a tube gear 26 at fixed speeds.

If the period of the alternating voltage applied to the piezoelectric device 4 and the number of teeth of the gears are set at predetermined values, time can be displayed by an hour hand attached to the tube gear 26, a minute hand attached to the minute gear 25 and a second hand attached to the number four gear 23.

In the electronic clock, the base plate 21 is connected to a positive power supply terminal. Whereas in the prior art there has been the restriction that a separate insulating structure must be provided by, for example, forming the base plate 21 and the number four gear 23 of an insulating plastic, this limitation is overcome because the oscillating body 3 is made of an insulating material. Thus, a current path between the power supply 10, which is, in this case, the positive power supply terminal connected to the base plate 21, and the ultrasonic motor is cut, and there is no requirement for forming the number four gear 23 for transmitting the output torque of the ultrasonic motor from the output of an insulating material.

Thus, an ultrasonic motor according to the present invention can be mounted in an electronic device without imposing structural restrictions being on the electronic

device and it is possible to obtain an ultrasonic motor which is simple to mount in a device and which can be used in a wide range of applications.

No corresponding structure is disclosed or suggested by the prior art of record.

Claim 1 stands rejected as being anticipated by Tokusima. However, Tokusima does not disclose the structure of claim 1, wherein an ultrasonic motor is formed so that at least one of the oscillating member, the pressing mechanism and the moving body which could, if formed of a conductor, provide a current path between at least one terminal of the power source and at least one electrode of the piezoelectric element, is formed of an insulating material.

Instead, Tokusima discloses a conventional device suffering from the same drawbacks pointed out by applicants.

In particular, Tokusima merely discloses a piezoelectric motor in which a stator comprising a pair of piezoelectric vibrators of plate form bonded with a metal is used as a power source and a mechanical vibration in two directions is converted into a rotary or linear motion through frictional force.

As shown in Fig. 1 of Tokusima, a first piezoelectric vibrator 1 of annular form is provided with electrodes 1a. A second piezoelectric vibrator of annular

form has the same construction as the first piezoelectric vibrator 1. The two piezoelectric vibrators are stacked so that the boundary of adjacent electrodes which is the minimum amplitude position of the second piezoelectric vibrator 2 is positioned in the vicinity of the middle of the electrode which is the maximum amplitude position of the first piezoelectric vibrator 1.

The first and second piezoelectric vibrators 1, 2 are assembled with a stator base 3 formed of any suitable material and having a larger thickness than that of the piezoelectric vibrators 1, 2. As shown in Fig. 2 of Tokusima, the assembly is used as a stator 4. A rotor 12 contacts the upper surface of the stator 4 and comprises an elastic body 13 formed of a friction material or elastic material and an acoustic material 14 joined thereto.

As noted, Tokusima fails to disclose the insulating structure of claim 1. There is no disclosure in Tokusima of a power source, a driving circuit and a structure designed to prevent a current path from being formed between the power source and a piezoelectric element. As can be plainly seen from Fig. 2 of Tokusima, for instance, the piezoelectric elements are not shielded in any manner from such a current path.

Similarly, the cited reference to Kanazawa fails to disclose a structure for an ultrasonic motor designed to prevent a current path from being formed between the power source and a piezoelectric element. As can be plainly seen from Fig. 1a of Kanazawa, electrodes of the piezoelectric element are not shielded in any manner from such a current path. Accordingly, incorporation of the Kanazawa motor in an electronic apparatus requires use of insulative materials in the electronic apparatus.

Kawai also discloses a conventional ultrasonic motor having a structure suffering from the same drawbacks the invention is intended to overcome.

Furthermore, an object of the present invention is to provide an ultrasonic motor with stable operating characteristics using a self-oscillating drive circuit formed by a driving circuit and a piezoelectric element. The claims recite a structure for an ultrasonic motor of the foregoing type in which insulation is provided between the self-oscillating drive circuit comprising an oscillating body, a piezoelectric element, an oscillation drive circuit and other members (supporting mechanism, moving body and pressing mechanism). Insulation is provided between the self-oscillating driving circuit and the other member is, for

example, to prevent the oscillating body from serving as an electric element in the self-oscillating driving circuit.

None of the cited references discloses a self-oscillating driving circuit and, therefore, none of the cited references discloses a structure for insulating between the oscillating body and the self-oscillating drive circuit.

The secondary references do not cure this defect. Japan '565 discloses a vibration isolation part 11c which isolates oscillation at the body part 11a from the rotation transmitting part 11d. The body part 11a, the sliding part 11b, the oscillation insulating part 11c and the rotation transmitting part 11d are made of the same resin material, molded as a unit and then only the surface of the sliding part 11b, coming into contact with the stator, is subjected to lapping with high planarity.

Japan '783 discloses an ultrasonic motor having a ceramic part or a part coated with a ceramic. In particular, a piezoelectric element 1 has an elastic ring 2 disposed thereon. A rotor 3 is disposed on the elastic ring 2. The surface of the rotor 3 is coated with a ceramic. Added durability is provided because the portion to be transmitted with a force is coated with a ceramic.

In view of the foregoing amendments and discussion, the application is now believed to be in condition for

allowance. Accordingly, favorable reconsideration and allowance of the claims are most respectfully requested.

Respectfully submitted,

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MAILING CERTIFICATE

I hereby certify that this correspondence is being deposited with the United States Postal Service as first-class mail in an envelope addressed to: Commissioner of Patents & Trademarks, Washington, D.C. 20231, on the date indicated below.

Bruce L. Adams
Attorney Name

Bruce L. Adams
Signature

April 19, 2000
Date